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IN THE

Supreme Court of the United States

October Term, 1938

No. 127

MACKAY RADIO AND TELEGRAPH COMPANY, INC.,
Petitioner,

vs.

RADIO CORPORATION OF AMERICA,
Respondent.

Respondent's Petition For Rehearing

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PETITION FOR REHEARING

Now comes the respondent, and petitions the Court for a rehearing for the following reasons:

1. *The opinion shows that the Court has disregarded portions of the record which negative its conclusion that the claims and disclosure of the patent in suit were improperly expanded by amendment.*

This Court has held that the disclosure of the application for the patent in suit was amended—

> "After *** respondent *** had acquired knowledge of the particulars of the structure and operation of petitioner's antennae"—

to expand the disclosure and claims to include petitioner's antennae, and that petitioner's antennae were not within the original disclosure. This holding ignores the *plain* language of the application *as filed*. It is contrary to the evidence. The uncon-

tradictable fact is that no amendment was made, either before or after the struct re of petitioner's antennae became known, that in the slightest degree expanded the scope of the claims in suit, or altered in any way the meaning of the disclosure upon which the claims in suit are based.

The antenna structures subsequently erected by petitioner were both described and claimed in Carter's application as filed (II, 1038, last paragraph; II, 1047, original claims 19 and 20). **Claim 16 (here in suit; original claim 20) was not amended in any way whatsoever after September, 1931,—which was eight months before petitioner built its antennae.** The necessary effect of this Court's opinion is that Carter's application did not mean what it said; yet there is no other meaning that can be given to this portion of the application and this Court has not suggested that there is. This Court has in effect **erased** from the specification an important part thereof, thereby doing a grave injustice to the patentee. *In fact, this Court has interpreted Carter's application in the very way that the preliminary draft of the application was modified, before filing, to prevent.*

2. *The opinion says that defendant's structures utilize angles that "differ from the angles of the formula" of the claims in suit, and the Court has found non-infringement for that reason, inter alia.*

This ignores the undisputed facts (1) that petitioner's antennae secure the result described by Carter,— *i.e.*, predominant radiation in the direction of the bisector of the angle between the antenna

wires,—a result not attained with any prior art V-antenna; (2) that *nine out of eleven* of the accused antennae depart from the angle of the empirical formula of the claims in suit by *less than one-half degree* (½°); (3) that one of them has an angle only two one-hundredths of a degree (.02°) *less* than that called for by Carter's empirical formula, and that another has an angle only seven one-hundredths of a degree (.07°) *greater* than the angle called for by Carter's empirical formula; (4) that the angles of three of defendant's eleven antennas are admitted by defendant's expert to be "as close as you can determine on that curve" to the angles called for by Fig. 12 of the patent (I, p. 309, XQ. 1398-1400); and that only one of petitioner's antennas departs from the angle specified by Carter by as much as two and one-half degrees (2½°); and (5) that the claims in suit call only for "substantially" the angle there set forth. A windstorm causing a pole to lean could easily make a change of angle greater than that which this court has treated as taking petitioner's antennae outside the scope of the claims.

3. *The Court has treated the mathematics, used in the patent specification to explain a theory of functioning of certain special wire lengths of a V-antenna, as though that explanation were itself the invention. It has limited the scope of the patent to the special cases for which the mathematical explanation was set forth. It has ignored the plain disclosure of the application as filed which specifically pointed out that ANY wire lengths could be used, provided the proper angle was chosen. It has ignored the fact that the application gave a formula and curve which was stated to be (and is)*

"sufficiently accurate" "for all practical purposes" for determining the proper angle for wires of any length.

The opinion gives no weight to the fact that the patent is on a simple structural arrangement, the essential factor being properly to *correlate* the elements. The empirical formula of the claims in suit and Fig. 12 of the patent, both contained in the application *as filed,* and unchanged in any respect whatever by amendment, complied with all of the statutory requirements of disclosure. They taught with certainty how to correlate the elements of the patented antenna, regardless of wire lengths used, to secure all the desired results. There can be no dispute on this point. Petitioner uses substantially the angles indicated by the curve and given by the formula and gets all the results taught by the patent.

4. *The Court holds (opinion, page 8, second paragraph) that the claims do not apply to wire lengths not multiples of integral half wave lengths*

> "both [1] because such structures are not within the invention described in the application and [2] because structures having wires of that length do not in fact exhibit 'the angle for the best directional propagation.' "

Both of these statements of the Court are entirely incorrect, and without support in the record. They constitute controlling errors in arriving at the holding of non-infringement. This is pointed out in detail in our brief herewith.

5. *The opinion ignores outstanding equities based on undisputed facts.*

(a) Carter produced a highly directive antenna of simple structure, having advantages over anything known in the prior art. He did this by means not apparent to or discovered by any of the many skilled engineers shown by the record to have been working intensively for several years on this same problem. This research was not only in the United States, but in England, France, and Germany also.

(b) Petitioner built its antennae *in exact accord* with detailed descriptions of respondent's commercial antennae previously published by Carter, *et al.*, in the Proceedings of the Institute of Radio Engineers, and after respondent's commercial antennae had fully demonstrated the truly startling efficiency and economy of the Carter antenna. Petitioner has made no claim whatever to any originality or independent research in this subject matter. It obtained the benefit of respondent's years of research by a direct copying of respondent's V-antenna structures, even to the odd quarter wave length wires which this Court has regarded as a distinguishing difference.

6. *The Court has erred in holding that the invention was a narrow one and should be narrowly construed.*

Although the opinion shows that this Court realized that various forms of directive antennas were old in the prior art, and that there had been much unfruitful effort, it has regarded as a narrow invention a structure that greatly improved on all prior art antennas.

While admittedly the change of form was simple, the result was to increase the effective directivity of

the old V-antenna (that of the second Lindenblad patent) many-fold. The increase in concentration of energy was far beyond what could have been predicted. What now seems simple to the Court was not apparent to many skilled scientists and research workers in this art, (many of whom are shown by this record to have been familiar with the Abraham formulae), during many years of work on short wave directive antenna development.

This Court has reversed the Court below upon grounds which, aside from the clear errors of fact upon which they are based, are purely academic, or technical. It has apparently given no weight to the evidence of substantial and practical achievement. It has considered the mathematics of a theory of operation, and has ignored the substance of a very practical and useful invention. The establishment of such a rigid and technical point of view by this Court in considering the validity and scope of a patent having such an undisputed record of substantial achievement and effect on its art, would indeed be a sad day for the patent system in this country.

Certificate of Counsel

We hereby certify that the foregoing petition for rehearing is presented in good faith and not for delay.

Respectfully submitted,

Jo. Baily Brown,

Abel E. Blackmar, Jr.,

Counsel for Respondent.

BRIEF IN SUPPORT OF PETITION FOR REHEARING

1. The Court Has Held That There Was Improper Amendment Broadening The Original Disclosure and The Claims in Suit

That the Court has regarded the alleged improper expansion of the disclosure and claims as a fundamental factor in its limitation of the patent to a scope not including petitioner's antennae, appears throughout the opinion, as we understand it. For example, on page 1, second paragraph, it says*:

> "After petitioner had answered and respondent, *as a result of the litigation*, had acquired knowledge of the particulars of the structure and operation of petitioner's antennae, Carter, respondent's assignor, *amended the statement of his invention in his application so as in terms to embrace a differentiating feature of petitioner's structure.*"

At the top of page 2, the opinion quotes with approval the statement of the Trial Court that

> "*The disclosure and the claims were broadened not only contrary to their original terminology, but to their spirit as well.* *** by those amendments the plaintiff attempted to mold the third Carter patent both as to disclosure and claims, *to cover defendant's antenna systems.* This could not lawfully be done."

On page 8, in the second paragraph, the opinion says:

> "we are not able to construe the application, *before amendment at least*, as embracing such an extension. And we think that *the attempt to extend the claims*, based on the application of the empirical formula, to

*Emphasis in quotations ours.

wire lengths not multiples of half wave lengths, must fail, both *because such structures are not within the invention described in the application****."

In the first paragraph on page 9 the opinion says that the claimed use of the empirical formula

> "thus *involved a departure from what Carter's application had described as his invention, and a contradiction of it.*"

In the next paragraph the opinion refers to—

> "This *attempt to broaden the only invention described in the application****."

These, and other statements in the opinion, as we understand it, refer to the erroneous belief that Carter's application *as filed* was limited in its disclosure and usefulness to antennas which *necessarily* comprised radiator wires made up of half wave lengths, and did *not* disclose or teach how to construct an antenna with wires of any intermediate lengths, and particularly that Carter's original teaching was not applicable to antenna wires made up of an odd number of quarter wave lengths, as are most of petitioner's structures.

The Court's position, as we understand it, is further that Carter's invention was based *solely* on applying to a V-antenna the mathematics derived by Abraham; and that since the Abraham mathematics dealt only with a single wire an integral number of half wave lengths long, therefore the Carter invention could not be applicable to wires not likewise an integral number of half wave lengths long, because he disclosed no mathematical determination of angles for such intermediate lengths.

The Original Disclosure Was Applicable To Wires Of Any Length And It Was Not Expanded By Amendment

With all due respect for this Court's opinion to the contrary, we assert that the documentary evidence shows beyond the possibility of doubt that Carter's application *as filed* disclosed and claimed and gave complete instructions for coordinating the elements of V-antennae having wire lengths *not* composed of integral half wave lengths (*e.g.*, odd numbers of quarter wave lengths as used by petitioner).

We shall here trace the matter in some detail, in spite of its tediousness, because it is vital to this case, and vital to prevent this Court from standing on a decision based on an utterly false premise.*

The Carter application *as filed* in 1930, (two years before petitioner's V-antennae were built), contained the following specific statement to the effect that the desired results could be obtained by using wire lengths *not* composed of integral half wave lengths.

> "Moreover it should be clearly understood that the wires of each unit can be of any length whatsoever provided they are placed at the correct angle for their length. For best tuning, the total over-all length of both of the wires and the 'U' loop terminating them should be effectively an integral number of half wave lengths, but, the portion forming the radiation element can be of any length. The law, giving the correct angle for lengths between odd and even number of half wave lengths, is not given due to its complexity, but the empirical formula and the

*In an appendix (pp. 29-35 below) we have treated the matter from a more technical viewpoint and have shown certain scientific misconceptions, evidenced by this Court's opinion, which appear to be at the foundation of its erroneous conclusions.

curve of Fig. 12 will be found accurate for all practical purposes, where the length of wire dealt with does **NOT** correspond to a whole number of half wave lengths." (II, page 1038)

This paragraph, without change in substance, appears in the *patent* at II, p. 501, lines 8-23. There is nothing whatever in any other part of the specification or subsequent history to negative the effect of the plain language used in that paragraph.

On page 6 of its opinion, this Court says that

> *Respondent insists* that *** [petitioner's antennae infringe] because, as *it argues*, the invention disclosed by Carter's application, *elaborated by amendment and broad claims*, embraces all V antennae arranged at an angle double the angle of the empirical formula, even though the length of the wires is not an exact multiple of half wave lengths, ***."

But respondent stands squarely on the Carter application *as filed*. It has not asked any construction based on any amendment to either specification or claims.

The statute* (Rev. Stat., sec. 4888) requires a description of the invention or discovery to be merely—

> "in such full, clear, concise, and exact terms *as to enable any person skilled in the art or science* to which it appertains, *** *to make, construct, compound, and use the same;* ***."

In his application, Carter described a V-antenna, specifically stated that "the radiation element can be of any length", and gave a formula (the empirical formula of the claims now in suit) and a curve (Fig. 12) for determining, with sufficient accuracy for all practical pur-

*Printed in full, last page of Appendix.

poses, the angle between the wires "where the length of wire dealt with does *not* correspond to a whole number of half wave lengths." Whether or not this formula was correct with mathematical precision, it was, just as he stated, "accurate for all practical purposes". It was sufficient to enable any person skilled in the art to erect and use the antenna and get the improved results disclosed. This has never been questioned by petitioner or its expert*. There is nothing in the record sustaining this Court's finding that the empirical formula and the curve of Fig. 12 of the patent "do not give the angle 'for the best directional propagation' for structures using this intermediate range of wire lengths". In fact, petitioner has demonstrated that the formula and curve are "accurate for all practical purposes" by constructing antennas utilizing angles 0.02° *smaller* and 0.07° *larger* than those of the formula and curve and securing the results described by Carter. (See pp. 16-18 below.)

Lest this Court think that the intention to cover, in the patent, antenna wires not an integral number of half waves long resulted from knowledge that petitioner was using wires of such lengths, we call the Court's attention to the following matters in the record which show, in unanswerable form, that it was the intention (and the right based on accomplished discovery) of the inventor to cover such antennae *ab initio*.

(1). Respondent introduced evidence to carry Carter's date of invention ahead of a V-antenna developed in 1930 by Bruce, and set up as a prior invention. In doing so the correspondence and test reports leading

*The most that Kelley, petitioner's expert, ever said was that the empirical formula did not give the "exact" angle and he would not say that it was wrong by as much as one-tenth of a degree (I, p. 238, 315). See the discussion of his testimony at pp. 34-35 below.

up to the filing of the Carter application were put in evidence. From these it appears that under date of May 14, 1930 (II, p. 667), Carter's attorney sent him "a rough draft of United States patent application papers covering your invention."

On May 20, 1930 (II, p. 692), Carter returned the first draft of the proposed patent application covering the invention here in suit, with certain penciled revisions noted thereon, and in an accompanying letter, *written to his attorney before the application was filed,* (and nearly two years before petitioner had any V-antenna) Carter said:

> "It appears to me that there are some statements in the specification which need a little clarifying. On page one one might gain the impression that it is essential for the proper working of this system that the length of the wires must be an integral number of half wavelengths. These wires can be any length whatever provided the angle is made correct to correspond. For the best tuning the total overall length of both the wires and the 'U' loop should be effectively an integral number of half wavelengths but the portion forming the radiation element can be of any length whatever. The law for determining the angle for lengths lying in between odd and even numbers of half waves was not given due to its complexity but the curves and the empirical formula give the correct values."

Thus, it is incontrovertible that Carter himself when returning the first preliminary draft of his specification saw that the first page of the specification might be construed as indicating that the antenna wires *must* be multiples of integral half wave lengths, to secure the desired concentration of radiation. Therefore, in order to prevent exactly the mistaken construction of his specification which this Court has made, he inserted in his original application the paragraph quoted at p. 9 above,

which is in almost the same words as his letter to his attorney.

(2). In this Carter was merely insisting upon a description of the invention that would **include an antenna that he had already built and tested.** The record shows (II, p. 699, 703, and p. 654) that Carter had erected and tested a V-antenna before filing his application, and had found it—

> "without doubt the simplest and cheapest of any system yet devised."

This antenna *had utilized antenna wire lengths that were not multiples of half wave lengths.* See II, p. 699, where at the middle of the page the Carter test report (made before application for the patent in suit) says:

> **"In the system tested the length [of antenna wires] was seven and three-quarter wave lengths."**

(3). Also, the I.R.E. paper published by Carter, *et al., eight months before petitioner built any of its V-antennas,* illustrates and describes (at II, p. 585) a V-antenna in which the radiating wires are 7¾ wave lengths long. *That is substantially the length of antenna wire used in several of defendant's antennas.* See Q. 452, I, p. 242, etc.

In view of such facts, can this Court possibly justify or leave of record its holding that Carter enlarged the scope of his application by amendments to sweep in a structure originating with Petitioner?

The Claims in Suit Were Not Expanded

The application as filed comprised claims 19 and 20 (II, p. 1047), which became claims 15 and 16 of the patent, the only claims now in suit. The original claims read as follows:

> **"19. An antenna comprising a pair of rela-**

tively long conductors disposed at an angle substantially equal to twice [formula identical with that of claims in suit omitted] degrees.

"20. An antenna comprising a pair of relatively long conductors disposed at an angle substantially equal to twice [formula identical with that of claims in suit omitted] degrees, and a similar parallel pair of conductors spaced an odd number of quarter wave lengths away from said first mentioned pair along the bisector of the angle of the conductors."

In the first action (II, p. 1053) the Patent Office Examiner said:

"All the claims are rejected as incomplete since, 'angularly disposed' does not sufficiently define the structure. These claims should recite with respect to what the conductors are angularly disposed.

• • •

"In claims 13-22, inclusive, the definitions of the symbols used in the mathematical expressions should be included in the claims, in order to distinctly point out the invention."

Responding to these purely formal requirements, applicant's attorney (II, p. 1058) amended each of claims 19 and 20 by inserting "with respect to each other" after the word "disposed" in line 2; changing the period to a comma and adding at the end of each:

"*l* being the length of the wire and lambda the operating wave length in like units."

These amendments were made on September 4, 1931, *and the construction of petitioner's V-antennas was not even commenced until June of* 1932. *Claim* 20, *which issued in the patent as claim* 16, *was not thereafter amended in any respect whatever. It had taken final form*

before petitioner had any V-antenna. And yet this Court has been led to hold that claim 16 was broadened to include a distinguishing feature of petitioner's antenna!

Claim 19, which issued as claim 15 in suit, was further amended on May 4, 1934, by adding to it the following (II, p. 1098):

> "and means in circuit with said antenna for exciting the conductors in phase opposition whereby standing waves of opposite instantaneous polarity are formed on the conductors throughout their length."

This amendment brought no matter into the claim not fully disclosed in the original application, which at II, p. 1038, said:

> "It should be mentioned here that energy to the radiators A, B, should always be fed thereto out of phase***."

And claim 2 of the original application (II, p. 1043) contained the same elements now under discussion:

> "2. A directional transmitting antenna comprising a pair of angularly disposed linear conductors, each substantially ~~a~~ plurality of half wave lengths long and open-ended, and, *means for exciting the radiators in phase opposition whereby standing waves of opposite instantaneous polarity are formed on the radiators.*"

The Trial Court was apparently adversely influenced by the fact that an amendment was made (II, p. 1123) adding the following paragraph to the specification:

> "By the term 'plurality of wave lengths,' or 'plurality of half wave lengths,' or 'several half wave lengths,' it is not intended that the wires so described shall necessarily be an exact or approxi-

mate integral number of such lengths, unless so specified, but rather that each of the wires so described shall be sufficiently long to include the lengths specified."

That amendment, whether proper or improper, has no bearing upon the two claims here in suit, because they do not contain, and never did contain, any reference to half wave lengths as a limitation or measure of the length of the antenna wires. Aside from that, the application as a whole clearly justifies the amendment that was made, if that be important here.

2. Petitioner's Angles Are Close Enough To Those Taught By Carter To Get Substantially The Same Results

The angles called for by the empirical formula of the claims in suit for the wire and wave lengths used by petitioner in its eleven antennae are indicated in the fourth column of the tabulation on the inside back cover of respondent's prior brief. In the third column, the angles actually used by petitioner are shown, the figures having been furnished by petitioner.

From this tabulation it will be seen that *nine of the eleven antennae differ from the angle called for by the empirical formula by less than one half degree* (½°). Petitioner's angles are neither uniformly more nor less than the corresponding angles of the formula, antenna No. 3 having an angle .02° *less,* and antenna No. 5 having an angle .07° *greater* than that called for by the claims. Such slight variations could hardly be avoided in practical field construction. The settling of a pole, or a windstorm could easily produce them. They would be imperceptible except by checking with a surveyor's instrument. They are utterly inconsequential in fact.

By the use of trigonometric tables (to five decimal places) and simple arithmetic, one finds that a variation of .02° in the angle of a V-antenna having wires 441.5* feet long means no more than the shifting of the antenna wires at the outer end of the V *less than two* (2) *inches.* Similarly, a variation of .07° in the angle of a V antenna having wires 565* feet long means no more than that the antenna wires must be moved *less than eight* (8) *inches* at the open end of the V. To carry this variation to its obvious absurdity as a distinguishing difference, if the 10-foot post hole in which the 80-foot poles used for erecting these antennae were *one* (1) *inch out of line from bottom to top of the post hole,* the wire attached to the top of the pole would thereby be thrown more than .07° out of the position it should occupy to be in exact conformity with the formula set out in the claims. *It is therefore apparent that it would be almost impossible to erect an antenna, as a matter of practice, that would conform to the formula with the exactness which this Court has indicated must be secured in order to come within the claims.*

Petitioner's expert Kelley specifically admitted (I, p. 309, in answer to XQ. 1399) that **three of petitioner's antennas are as close to the Carter angle as you can determine by using the curve of Fig. 12 of the patent.**

Petitioner offered no evidence to show how or why it arrived at its angles, and made no claim to any original research in connection with the selection of its angles. Since its antennae were built several months after the publication of Carter's Radio Institute paper, and after respondent had built and publicized its commercial antennae, it is reasonable to conclude, and it has

*These are the lengths of the wires in petitioner's antennas having the variations referred to in this discussion.

not been denied, that petitioner followed the teachings of Carter in determining the angles for its V-antennas.

This Court's opinion says that

> "it is not material that the variations are small between the angles used by petitioner for wire lengths of multiples of quarter wave lengths and those obtained by application of the empirical formula" (page 11, second paragraph).

We assume the Court made this statement because of its belief that Carter's disclosure did not apply at all to wires of odd numbers of quarter wave lengths, rather than because the Court believed that that slight difference of angle *per se* avoided infringement. Otherwise this decision would be furnishing an out for infringement of any patent addressed to a structure defined in terms such as "straight," "square," "circular," "elliptical," "perpendicular," etc. Such a conclusion would be contrary to this Court's decision in *Winans v. Denmead*, 15 How. 330.

In so far as the holding of non-infringement is based on slight and non-functional variation from a claimed structure, the advantages of the patented structure being fully attained in spite of the variation, the Court here ignores the principle laid down in *Sanitary v. Winters*, 280 U. S. 30, 42, that when the substance of an invention is appropriated, infringement will be found even where the exact letter of the claim is avoided.*

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*In the present case, the exact letter of the claim is not avoided because the claims in suit call for "substantially" the angle of the formula.

The Prior Art did not Limit Carter to an Exact Angle

On page 11 of its opinion, this Court indicates that Carter had to define his angle "with mathematical precision" to avoid prior art. But the *only* prior art directive antenna composed of long wires in V formation fed in phase opposition was that described in the second Lindenblad patent. The angle Lindenblad specified for his purposes was less than 12° for wires "five to ten waves long"; admittedly, the Lindenblad antenna did not operate, as Carter's does and as petitioner's do, to secure predominant radiation in the direction of the bisector (see petitioner's Exhibits CC, DD, II, pp. 897, 898).

On this point the trial court found as to the Lindenblad patent:

> "The second Lindenblad Patent 1,927,522.
>
> "This patent is for a traveling wave antenna. No evidence was offered of any adoption or use thereof by anyone. All of defendant's antennas charged to infringe are of the standing wave type. *** This patent is not directed broadly to a V-type antenna as **it is wholly inadequate of disclosure because the proper angle between the antenna [fol. 1369] wires constituting the legs of the V is not given and no means are disclosed by the patent to enable one to determine the proper angle.** Only with proper angles could the stated objects of the patent be attained, that is, that the **main lobe of radiation would be in the plane of the wires and on the bisector of the angle between the legs of the V.**" (II, p. 1149)

> "*No instruction is given in the* [Lindenblad] *specification as to the proper angle, between the legs of the V, and such instruction is necessary be-*

cause without the proper angle, maximum radiation in the direction of the bisector of the angle would not occur, as at certain values of the angle, zero radiation on the line of the bisector is obtained." (II, p. 1150, folio 1370).

And on the same subject, petitioner's expert said:

"Q. 340. Do you find *any instructions in the Lindenblad patent as to the proper angle between the legs of the V antenna shown in Fig.* 2?

"A. *No, I don't.*"

"Q. 341. Do you find in the Lindenblad patent *instructions as to the necessity for or how to obtain the angle between the legs of the V of Fig.* 2 *in order to obtain radiant action predominantly along the direction of the axis of the conductor system?*

"A. *I don't.*" (I, p. 215)

As to Bruce, this Court is simply in error in finding that, prior to Carter, he had plotted a graph "showing the directional radio activity of a V-antenna". Bruce's graph (II, 902) related only to a **single** wire and was **designed to show the angles at which single wires of** different lengths should be **tilted with respect to the ground** to secure maximum response to a horizontally arriving signal. It had nothing to do with a phase-opposition V-antenna. Bruce himself, although a skilled engineer working with several assistants continuously on the problems of short wave directive antennas from 1924 on, did not see any advantage to be gained by application of a preferred angle to antennas of the type here involved, until after the Carter antenna had been invented, set up, and tried out.

Carter was the *first* to teach the art how to construct a V-antenna to secure predominant radiation in

the direction of the bisector. *There was no close prior art requiring Carter to restrict his claims to an exact angle.* Petitioner has followed Carter, not the prior art.

The record shows that **the V angle may be varied as much as 2½° and still get predominant radiation on the bisector twelve times as strong as that of a standard comparison dipole** (Hogan, I, p. 151). The **exact** angle is the **optimum**, but the new result of Carter does not require **exactness**, and infringement is not avoided by slight differences. The **only** angle for a V-antenna given in the prior art was the 12° angle of Lindenblad for **all** wires between five and ten wave lengths long. **That angle is from 20° to 33° off Carter's optimum angle.** But that is the **only** prior art to limit Carter to an exact angle for his V-antenna. **His object of maximum concentration in the direction of the bisector and suppression of useless radiation** is clearly attained by angles having some permissive variation. We submit that the test should be whether the accused device secures the Carter objectives, or only the Lindenblad prior art results.

3. Carter Used the Abraham Mathematics For Theoretical Explanation, But In Addition He Gave Practical Directions Applicable To The Cases Not Treated by Abraham

This Court has treated the Carter disclosure as though it were of no value except in so far as it consisted in applying the old Abraham formula to V-antennae. Since the Abraham formula was worked out with respect to and dealt only with a single wire made up of integral half wave lengths, this Court has assumed that since Carter did not give any mathematical proof of the application of his "empirical formula" to wires of intermediate lengths, he taught nothing with respect to

the use of wire lengths comprising an odd number of quarter wave lengths, such as petitioner uses. So to hold is utterly to ignore the plain wording of the original application, and to fail to see the substance and value of what Carter told the art to do to get the desired results.

The Court has given no weight to the fact that Carter disclosed in his *original* application *three* formulae. The *first* of these, stated, for example, in claims 9, 11, and 13 (not in suit), is applicable to antennae in which the radiating wires are each made up of an *odd* number of half wave lengths. The *second* formula, stated, for example, in claims 10, 12, and 14 (not here in suit), is applicable to antennae in which the radiating wires are each made up of an *even* number of half wave lengths.

But Carter did not stop there, this Court to the contrary notwithstanding. He went on, empirically developed, tested by actual construction and trial of an antenna to which the first two formulas did not apply, and stated in the original application *a third formula giving the optimum relation between wire length, wave length, and angle,* for securing maximum radiation in the direction of the bisector of the angle of a V-antenna,—

> "where the length of wire dealt with does *not* correspond to a whole number of half wave lengths." (Original application, bottom of I, p. 1038).

This Court's opinion seems to assume that because Carter omitted from his specification a mathematical discussion of the law applying to radiation from wires *not* made up of half wave lengths "because of its complexity,"—that therefore the empirical formula of the two claims in suit must be incorrect, or even if correct, that it was not a part of the invention Carter intended to describe. We confess our utter inability to follow the

Court's reasoning on this point. The plain words of the application are directly to the contrary.

4. The Claims Apply To Wires Not Multiples Of Half Wave Lengths, And When So Applied The Same Advantages Are Obtained As Follow Proper Use of Wires That Are Multiples Of Half Wave Lengths

(a) The Court's error in holding that the Carter empirical formula was not intended to apply to anything but wires composed of integral half wave lengths has been discussed above.

(b) Its statement that wires not made up of integral half wave lengths—

> "do not in fact exhibit 'the angle for best directional propagation' "—

follows a finding of the trial court that was clearly erroneous.

The only testimony in the record to the effect that the Carter empirical formula and the curve of Fig. 12 are not accurate when applied to intermediate wire lengths, is that of petitioner's expert Kelley, who merely stated as a *conclusion* that it was not "exact" (I, 238, Q. 440). *He did not give any calculation or figures to show to what extent if any he had found Carter's empirical formula inaccurate in fact.* He never said that it was inaccurate for *practical purposes.* On the contrary, as will be seen from his cross-examination on this point, he was unwilling to state that the extent of alleged inaccuracy was as much as one-tenth of a degree. See XQ. 1469, I, p. 315.

The controlling consideration is that Carter taught the art that maximum radiation could be concentrated in

the direction of the bisector of a V-antenna by proper correlation of the structural elements, and he gave a curve and an empirically arrived-at formula that indisputably are sufficiently accurate for all practical purposes to teach workers in the art how to coordinate the V-antenna elements to get the new result Carter had discovered. That the curve and empirical formula are sufficiently accurate for that purpose is shown by the fact that most of petitioner's antennas have *followed the curve almost exactly* and have obtained the exceedingly valuable results that Carter said would be obtained, *by the coordination taught by Carter's empirical formula.* That would seem to be the real test on this point.

5. Equities And Public Policy Are All In Favor Of Respondent

There is no doubt from the record but that Carter made an important discovery and gave something new and useful to the art. For example, there is no contradiction of any of the following facts:

From 1924 on, many skilled radio engineers were continuously working on the problem of improving short wave directional antennae.

This investigation was carried on continuously not only in this country, but in England, France, and Germany. The Marconi Company arrived in 1926 at a directive antenna that went into world-wide use. Respondent bought and erected two such antennae at a cost of between $100,000 and $175,000 for each. The American Telephone & Telegraph Company after continuously working on this problem through a corps of skilled engineers from 1924 through the times involved

in this case erected in 1929 an antenna of the very costly suspended-curtain type for its short wave transatlantic communication. Respondent itself built and tried out and put into commercial service numerous directive antennae of more expensive and less efficient forms before Carter arrived at the simple and startlingly effective antenna covered by the patent in suit. At a cost of about $5,000 results equal in effective directivity to those of the Marconi antenna were attained, and there were other advantages, such as much lower cost of maintenance, simplicity of adjustment, etc.

After test of Carter's antenna had shown its outstanding advantages (using a 7¾ wave length antenna for that test), *respondent adopted for all further construction of antennae, the Carter structure.* Petitioner, which had previously used other forms of antenna, after respondent had built, used, and publicized the merits of the Carter antenna, itself adopted the V-type antennae. This was because, as its chief engineer said, they were "the most effective" antennae known to him that he could erect for the money he had to spend. (Pratt, I, p. 204).

Petitioner makes no claim whatever to having taken any part in the years of world-wide research with respect to the development of short wave directive antennae, nor to any originality of thought in its own design. Obviously it simply appropriated the results of respondent's research.

Under such circumstances we submit that every inclination of this Court should be to resolve all doubts against petitioner. The public interest is vitally involved in rewarding such a contribution to progress of an art. To do otherwise is to discourage research and invention, and to acquit the commercial trespasser.

6. The Invention Was One of Great Practical Value And The Patent Is Entitled To A Liberal Construction

We respectfully submit that in this case the Court has misunderstood a point which is fundamental in any patent case,—the nature and scope of the invention Carter made. The diagrams in the record illustrate our point.

Figs. 1*a* and 1*b* of the Carter patent (II, p. 492) illustrate the single wire 2-2 discussed by Abraham and the predominant radiation which surrounds it, Y, Y, Y, Y. It will be remembered that this radiation is in hollow cone form, which we have compared in our prior brief, p. 13, to the walls of a megaphone.

Petitioner's Exhibits CC and DD (II, p. 897, 898) illustrate the field of radiation from a Lindenblad V-antenna with the angle given by Lindenblad. The concentration of the radiation is very poor. The maximum concentration is outside the V and goes out in four widely separated directions. Of necessity the great majority of it goes out in unwanted directions and this could not be cured by use of a "reflector" antenna.* That accounts for the fact that the Lindenblad antenna was never used except experimentally. Having tried it out Lindenblad went on to develop other forms of antenna (II, p. 544).

What Carter did was to take the Lindenblad V antenna of the prior art and so correlate the wire length, wave length, and angle that a portion of the cone of radia-

*We here note that Lindenblad did not suggest the use of a "reflector" with his antenna: He proposed to secure unidirective action by the use of traveling waves. This Court was in error in saying (Opinion, p. 3) that,

> "the prior art had made use of an arrangement of wires, parallel to the wires of the angular antenna, as a 'reflector'***."

There is no evidence in the record to that effect.

tion issuing from one of the wires was in line with a corresponding portion of the cone of radiation issuing from the other wire. The remaining portions of the main cones of radiation and all the minor cones would be expected to result in quite large amounts of radiation in random, unwanted, and useless directions. At most one would expect no more than a doubling of the radiation in the desired direction.

But the extraordinary and unexpected result which Carter found by test actually to come about was, we submit, sufficient to lend the utmost dignity to his invention. Instead of having in effect portions of two separate cones of radiation, combining only in the comparatively narrow common area (actually about 10°-20° wide and thick), and therefore merely *adding* the individual radiations that were common in location and direction, **Carter found that the result was quite different from what was to be expected. Unpredictably the proper V-arrangement cancels most of the radiation except that issuing in the direction including the superposed portions of the cones.** Substantially all of the energy radiated in the directions of the other portions of the two main cones, and also in the directions of the minor cones (which energy one would expect to be wasted from a practical point of view), appeared as energy in the desired direction. See Hogan, I, p. 122. The resulting horizontal distribution of radiation is shown in Fig. 3 of the Carter patent (II, p. 494).

The advance made by Carter over Lindenblad is shown to scale, in respondent's Exhibit 53. The Lindenblad radiation in the horizontal plane of the wires is shown at II, p. 720; and that of Carter for like wave and wire lengths at II, p. 722. The same respective results in the vertical plane of the bisector are shown for

Lindenblad at II, p. 721, and for Carter at II, p. 723.

Nothing in Abraham or Lindenblad's work taught that such a result would follow such an arrangement. No one had ever proportioned a V-antenna to get that result before Carter, or foreseen or suggested that such a result might follow. Carter determined it by actual test, getting results that could not have been predicted by any process of "logical application of known scientific law," and not taught directly or indirectly by Abraham. The astonishing results of Carter's tests of his antenna, made and reported in detail before he filed his application for patent, are shown by his report to his engineering superior. See II, pp. 699-708, particularly page 702.

We submit that such a discovery and its practical application constitute an invention entitled to liberal treatment and that the Court was in error in regarding the invention as a narrow one, and the patent as one to be strictly construed and only infringed by precise copying of a specific example. It is entitled to a construction sufficiently broad to include anything which by substantially the means specified secures the new result which Carter discovered, a result far superior to the results obtainable with the prior art arrangements.

Respondent should be given opportunity to make clear to the Court the errors in its decision.

Respectfully submitted,

Jo. Baily Brown,

Abel E. Blackmar, Jr.,

Counsel for Respondent.

February 20, 1939.

APPENDIX A

As to Certain Scientific Misconceptions In This Court's Opinion

We have studied this Court's opinion at length in an effort to determine the basis for its failure to give effect to the plain statement in the Carter application that his invention was applicable "where the length of wire dealt with does *not* correspond to a whole number of half wave lengths." We have found a number of scientific errors or apparent misapprehensions which may have led to the decision. At the risk of being unduly abstruse, we wish to call these matters to the Court's attention.

(1) In foot-note No. 1 (page 4 of the opinion), it is stated:

> "When the length of the wire is a multiple of half wave lengths, the oncoming and reflected waves, traveling at the same velocity, occur simultaneously, *differing in this respect* from the waves in a wire of a length intermediate a multiple of half wave lengths, and *with different effects upon the resulting radio energy,* presently to be noted."

This statement indicates to us that this Court thinks that true, symmetrical, standing waves are not present on an antenna wire that is, for example, an odd number of quarter waves long. Such a misconception is easy to understand for it might seem that, with waves of such length, the oncoming and reflected waves do not "occur simultaneously" and would be "jumbled up" and could not exist in symmetrical form. Possibly this might be so were it not for the fact that the two wires which constitute the V antenna are in all cases *tuned,* as by the U loop referred to by Carter or by equivalent means. As Carter states (patent, II, 501, lines 11-16):

> "*For best tuning*, the total *over-all* length of both of the wires *and* the U loop terminating them should be effectively an *integral number of half wave lengths*, although the portion forming the radiation element can be of *any* length."

Thus the antenna, as a whole, is, effectively (*i.e.*, electrically), a multiple of half wave lengths long regardless of the length of the radiating wires. As Hogan said (I, 112, Q. 58) the type of antennae that we have in this case

> "are *tuned* so that the waves *build up in the standing wave form.*"

And, referring specifically to petitioner's antenna No. 2, the antenna wires of which were 7.74 wave lengths long, Hogan pointed out that the antenna

> "was *tuned* and adjusted by means of the U-shaped loop, extending from MN to the antenna point CD, ***" (I, 139)

and also (I, 137) that this antenna has "the desired standing waves."

And petitioner's expert Kelley said (I, 215) that petitioner's antennae are of the *standing wave type* and (I, 210) that

> "An antenna of the standing wave type by its very nature should be *tuned* for best operation."

Furthermore, *petitioner's* Exhibits Y and Z (II, 822, 823) show that this Court was incorrect in stating that there are "different effects upon the resulting radio energy" in the case of odd quarter wave length wires.* Exhibit Z also shows that Carter's empirical formula is

*The minor lobes have a somewhat different form, but that is of no importance here. Kelley admitted (I, 316, XQ. 1477) that the main lobes "are pretty near the same" in magnitude.

correct for a wire 7¾ wave lengths long. The formula shows an angle of 17.8° between the predominant direction of radio activity and the wire (I, 139): *Petitioner's Exhibit* Z *shows the same angle* so far as can be determined therefrom. (See Kelley's testimony at I, 317-8, XQs. 1493-6.)

Petitioner has always contended that all of its antennae are of the true standing wave type. The Trial Court found as a fact that they are. See II, p. 1149.

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(2) This Court states (opinion, p. 8) that wires not multiples of half wave lengths

> "do not in fact exhibit 'the angle for the best directional propagation.'"

Again—

> "It [Carter's empirical formula] reveals no scientific law applicable to wire lengths which are intermediate of multiples of half wave lengths, ***."

And again (pp. 8-9)—

> "Neither the empirical formula nor its graph gives any clue to the directional radio activity resulting from the use of wire lengths intermediate of multiples of half wave lengths, ***."

We believe that the record shows that this Court has here fallen into scientific error. We have pointed out above that *petitioner's* Exhibit Z shows that the empirical formula states the angle between the main lobe of radiation and the wire correctly. *Petitioner's* evidence also shows that structures having wires of lengths intermediate of multiples of half wave lengths *do* in fact "exhibit 'the angle for the best directional propagation'" and that the empirical formula and the graph of Fig. 12

not only give a "clue to the directional radio activity resulting from the use" of such intermediate wire lengths but *give all the information as to that subject that is necessary to build an antenna which utilizes the best angle between the wires.*

Thus Kelley testified (I, 243) that

> "The result of this is that *better* directivity results by *departing from an integral number of half wave lengths,* and going to an odd number of quarter wave lengths,"

and explained that this is due to there being a smaller amount of energy in the *minor* lobes in the latter case. **And petitioner's use, for an antenna having wires 7.69 wave lengths long, of an angle differing from Carter's by only 0.02° shows that Carter gave all the information that was necessary to construct a directional antenna using wires of such length.** As we have pointed out above (p. 17), 0.02° difference, in the case of a wire 441.5 feet long, means a displacement, at the end of the wire, of *less than* 2 *inches,*—a displacement which might be caused by wind pressure on the wire or the pole or by negligible settlement of the pole.

Suppose there were no logical, scientific justification for Carter's method of deriving his empirical formula, what difference can that make so long as the formula, when derived, was accurate for all practical purposes and was sufficient (when taken with Carter's specification) to instruct one skilled in the art to construct an antenna with all the advantages claimed by Carter? Why is it "legerdemain" to say that Carter's invention included a structure described and claimed by him, even if the formula defining that structure had been developed on a basis not mathematically explained in detail?

(3) This Court states (opinion, p. 9) that the empirical formula "had been devised as a shorthand expression" of the Abraham law and that use of it in connection with wires intermediate in length between multiples of half wave lengths was a use,—

"for a purpose for which it was not devised***."

These statements disregard the plain statement of the application as filed that the formula is applicable "where the length of wire dealt with does not correspond to a whole number of half wave lengths." As this statement was a part of the application, it must be given effect. The Court is plainly in error in its conclusion.

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(4) Referring to the first two paragraphs of page 10 of the opinion, the amendments to the application did not in any way affect the reference to the Abraham law nor "modify the Abraham formula." That law still stands, in the patent, as an explanation of the radiant action where the wires are an *integral* number of half wave lengths long; the claims embodying the Abraham formulas (Nos. 9-14) are still for antennae with wires an odd or even number of half waves long; and the letter n of the Abraham formula is still "the number of half wave lengths contained in the wire." The amendment defining the terms "plurality of wave lengths," or "plurality of half wave lengths," or "several half wave lengths" (II, 502, lines 35-42) *does not apply to any of the claims embodying either the Abraham or the empirical formula;* it applies only to claims (such as claim 1) that embody one or the other of those terms.

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(5) At pages 10-11 of its opinion, this Court says:

"*The testimony warrants the conclusion* that differ-

ences in wave effect already noted, when wires of other than exact multiples of half wave lengths are used, produce, through consequent changes in 'radiation resistance,' *differences in the angle* of directional radio activity not calculable by the formulae of the patent. It establishes that they *do not give the angle 'for the best directional propagation'* for structures using this intermediate range of wire lengths, ***."

This is correct in so far as it applies to the *Abraham* formulae. But applied to the empirical formula, the testimony shows that it is not correct. The only testimony that might be thought to support the conclusions of this Court and the trial court on the point is Kelley's categorical answers to Q. 440 (I, 238) and to XQs. 1457-8 (I, 314-5). The remainder of his testimony, however, does not support these answers.

As to his direct examination, he said (I, 239) that the inaccuracy of the empirical formula would be "indirectly" shown by the radiation resistance curves. He then discussed such curves (I, 239-244, Qs. 442-455) but *never once asserted that they had anything to do with the ANGLE of radiation;* instead, he merely showed that there was less radiation in *undesired* directions when the wires were other than multiples of half wave lengths long.

His cross-examination on this point is at I, 315-318 (XQs. 1459-1496). He again referred to radiation resistance curves, but only to show that "it would not be safe to assume" that the empirical formula was correct (XQs. 1459-1460). As to the extent of supposed error in the empirical formula, Kelley here testified:

"XQ. 1462. Can you tell me by how much the angle departs from the correct angle at a point say

between six and one-half and seven wave lengths?

"A. *No, I do not recall how much.* At some point *they are calculated* and there is a difference.

"XQ. 1463. And what is the order of the difference?

"A. I don't remember that, *it is not a large amount,* I can tell you that.

"XQ. 1469. It might or might not be *one-tenth of a degree?*

"A. Well, *that I don't remember also.*"

And note that he *never produced the calculations* which would show the supposed difference.

We have pointed out elsewhere the affirmative evidence that the empirical formula *does* "give the angle 'for the best directional propagation' for structures using this intermediate range of wire lengths."

We therefore submit that the finding of this Court to the effect that it does not is clearly erroneous and is contrary to the evidence.

APPENDIX B

Sec. 4888. (U. S. C., title 35, sec. 33.). Before any inventor or discoverer shall receive a patent for his invention or discovery, he shall make application therefor, in writing, to the Commissioner of Patents, and shall file in the Patent Office a written description of the same, and of the manner and process of making constructing, compounding, and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art or science to which it appertains, or with which it is most nearly connected, to make, construct, compound, and use the same; and in case of a machine, he shall explain the principle thereof, and the best mode in which he has contemplated applying that principle, so as to distinguish it from other inventions; and he shall particularly point out and distinctly claim the part, improvement, or combination which he claims as his invention or discovery. The specification and claim shall be signed by the inventor. No plant patent shall be declared invalid on the ground of noncompliance with this section if the description is made as complete as is reasonably possible.

pp. 8+11,

SUPREME COURT OF THE UNITED STATES.

No. 127.—October Term, 1938.

Mackay Radio and Telegraph Company, Inc., Petitioner, *vs.* Radio Corporation of America.	On Writ of Certiorari to the United States Circuit Court of Appeals for the Second Circuit.

[January 30, 1939.]

Mr. Justice Stone delivered the opinion of the Court.

The questions presented for decision by the petition for certiorari are whether the Carter patent, No. 1,974,387, of September 18, 1934, for a directive antenna system for use in radio communication, is valid and is infringed by antennae structures used by petitioner in such communication.

Respondent brought the present suit in the District Court for eastern New York to enjoin infringements of four patents relating to radio antennae or their operation. Two were those of Carter and two those of Lindenblad. Of these only the second Lindenblad patent, No. 1,927,522, of September 19, 1933, for an antenna for radio communication, is of present importance. When the suit was begun the application for the third Carter patent, with which we are presently concerned, was pending. After petitioner had answered and respondent, as a result of the litigation, had acquired knowledge of the particulars of the structure and operation of petitioner's antennae, Carter, respondent's assignor, amended the statement of his invention in his application so as in terms to embrace a differentiating feature of petitioner's structures. After this patent was issued respondent was permitted to file a supplemental bill charging infringement of it. The suits were consolidated, and the parties proceeded to trial on the issues of the validity and infringement of all five patents.

After taking the voluminous testimony of numerous witnesses, the trial court found that none of the patents in suit was infringed and decreed that the suits be dismissed. 16 F. Supp. 610. It held that none of them was a pioneer patent; that none had been employed by any one; that respondent's commercial structures did not follow the teachings of any of them; and that consequently

they were not entitled to a broad construction. With respect to the Carter patent in suit it said: "The disclosure and the claims were broadened not only contrary to their original terminology but to their spirit as well." And " . . . by those amendments the plaintiff attempted to mold the third Carter patent both as to disclosure and claims, to cover defendant's antenna systems. This could not lawfully be done."

On appeal from so much of the decree as related to the second Lindenblad patent and the third Carter patent, the Court of Appeals for the Second Circuit affirmed as to the Lindenblad patent, but reversed as to the Carter patent, holding Claims 15 and 16 valid and infringed. 96 F. (2d) 587. We granted certiorari, — U. S. —, because of the nature and importance of the case, on a petition which urged as grounds for its allowance that validity and infringement of the Carter patent were in doubt and that, as petitioner is the only competitor of respondent in the business of world wide public radio communication, further litigation, resulting in conflict of decision among circuits, was improbable.

In ordinary broadcasting, radio waves are projected in all directions from the sending station. In radio communication it is advantageous and has long been the practice to use a directive antenna by which the waves of radio activity emanating from it are projected as a beam in the direction of the receiving station. In practice the beam is directed at an angle from the earth's surface toward the ionized layer of the stratosphere, or Heaviside layer, from which the beam is deflected toward the earth's surface in the compass direction of the receiving station. In more recent years it has been the practice to use relatively short wave lengths for radio communication.

The radio waves are generated at the sending station by feeding an oscillating electric current of appropriate character into the wire or wires of the antenna. The electric waves in the wires energize radio activity, which the antenna projects as radio waves toward the receiving station. By modulating or interrupting the current, corresponding modulation or interruption of the radio waves is effected, which may be used as a means of transmitting any desired signal. The waves, as modulated, impinge on the antenna of the receiving station devised to receive and utilize them as a means of controlling, with corresponding modulation, an electric current which in turn actuates a mechanism contrived to give audible or visual expression to the transmitted signal.

The effective part of the antenna is a copper wire from which the radio waves are radiated, supported on towers or poles at a height above the ground depending on the wave length used. The wire may be parallel with the earth, or vertical, or arranged at an angle, depending upon the function to be performed. Before Carter, antennae of two or more wires in varying arrangement had been used. The second Lindenblad patent showed an antenna of two wires arranged at an angle in the form of a V or an X, and it pointed out that in such an arrangement radiation will take place in the direction of the axis or bisector of the angle of the diverging wires, and that "the spacing at the open end [of the wires], while variable over a great range, should be in the neighborhood of a fifth of the length, and the length of each antenna section should be of the order of magnitude of five to ten waves long."

While such an arrangement projects the radio waves principally in two directions along the bisector of the angle of the antenna wires, the prior art had made use of an arrangement of wires, parallel to the wires of the angular antenna, as a "reflector" by which the radiation was projected as a beam in one direction away from the reflector and along the bisector of the angle of the wires.

The present Carter patent is for an "antenna system utilizing standing wave phenomena." Like the second Lindenblad patent, it is concerned with a V antenna by which the principal radiation is directed in the plane of the wires along the bisector of their angle. The disclosure of the patent, in which the court below found invention, was that the best directional radio propagation by the V type antenna is obtained with a structure in which the angle of the wires, their length, and the length of wave propagated are in a definite mathematical relationship expressed by a formula disclosed in the specifications.

In explaining his invention, Carter pointed out that "It is known that when a wire having a length greater than the operating wave length is excited in such manner that standing waves are produced thereon, radiation will occur principally in the direction of symmetrical cones having their apices at the center of the wire. Such is the case with a wire having a length equal to a plurality of one-half wave lengths at the operating frequency. The radiation pattern produced in such instance appears, in cross section, in the form of symmetrical cones about the wire. The present invention, which makes use of these phenomena, in its most simple aspect employs a pair of open-ended wires energized in phase op-

position to have standing waves throughout the length of the wires, the wires having such angular relation with respect to each other as to obtain a highly directional, efficient and simple antenna system."[1]

The patent states the mathematical formula by which the desired relationship is secured, which shows that the appropriate angle between each of the antenna wires and their bisector depends upon the wave length to be propagated and the use of antenna wires of a length which is a multiple of half wave lengths.[2]

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[1] Understanding of the disclosure and other features of the patent requires a brief explanation of its terms. The term "long", as applied to an antenna, means a wire which is long in relation to the wave length used. The term "standing waves", as distinguished from "traveling waves", describes the phenomenon manifested when an oscillating electric current of radio frequency is communicated to one end of a wire which is open at the other (that is, not in a closed circuit) and sufficiently short so that the waves have not completely radiated their energy before reaching the end of the wire. The waves will then be reflected back along the wire, and the energy of the reflected waves tends to unite with that of the oncoming waves of the same periodicity, so as to produce standing waves along the wire. As the velocity of the radio wave in space is approximately that of the current waves in the wire, the number of complete standing waves on the wire is always exactly the same as the length of the wire divided by the wave length. When the length of the wire is a multiple of half wave lengths, the oncoming and reflected waves, traveling at the same velocity, occur simultaneously, differing in this respect from the waves in a wire of a length intermediate a multiple of half wave lengths, and with different effects upon the resulting radio energy, presently to be noted.

When oscillating current is so related to the length of wire that the energy of the former is exhausted by radiation before or when the waves reach the end of the wire, there is no reflection of the waves, and they travel in one direction only toward the open end of the wire. They are denominated "traveling waves". In professional parlance, wires producing reflected, and hence "standing" waves, are electrically of finite length. Those of sufficient length to avoid reflection and thus carry waves flowing in only one direction are said to be electrically of infinite length.

[2] The specifications state: "By considering a long wire the equivalent of a very large number of very short, (Hertz) oscillators and by adding up the field components at any point P having a direction angle θ relative to the axis of the wire, where the point P is a great distance from the wire as compared to the length of the wire such that all lines from point P to any point on the wire are essentially parallel, it can be shown that the field strength H is given by the following proportionality for a conductor an odd number of half wave lengths long:

$$H \propto \frac{\cos\left(n\frac{\pi}{2}\cos\theta\right)}{\sin\theta}$$

The letter "n" indicates the number of half wave lengths contained in the wire.

For a wire an even number of half wave lengths long, in similar fashion, the field strength "H" is given by the following proportionality:

$$H \propto \frac{\sin\left(n\frac{\pi}{2}\cos\theta\right)}{\sin\theta}$$

Where n as above indicates the number of half wave lengths on the wire."

The significance of the formula lies in the fact that the angle between the wire and the direction of greatest radio activity is a trigonometrical function of two variables, the wave length used and the "number of half wave lengths contained in the wire", and that, as the application stated, the use of the formula in practice presupposes the use of a wire whose length is a multiple of half wave lengths. The patent then explains that the angle θ of the formula is the angle between each wire of the V antenna and its bisector—in other words, that the angle of the wires of the antenna is twice θ and hence, like the angle of the formula, is a function of the wave length and the length of the wires, which are each a multiple of half wave lengths long.

Carter did not invent the formula. It had been developed by Abraham and published in a scientific journal thirty years before. Annalen der Physik, 1898, Physikalische Zeitschrift, March 2, 1901. Abraham's formula expressed the scientific truth that when radio activity is projected from a charged wire of finite length, i.e., one having standing waves, and having a length of a multiple of half wave lengths, the angle between the direction of the principal radio activity and the wire is dependent on wave length and wire length, which is a multiple of half wave lengths. Lindenblad had described his antenna as using either standing or traveling waves and, as we have seen, had taught that with an arrangement of antenna wires at an angle, radiation will occur substantially in the direction of the bisector of the angle and that the preferred angle was dependent upon an indicated relationship between wire length and wave length.

It is plain, therefore, that the Carter invention, if it was invention, consisted in taking the angle of the Abraham formula as the angle between each wire of the V antenna and its bisector. By so doing he brought the cones of principal radio activity, each having one of the wires of the antenna as its axis, into conjunction at their periphery and along the bisector of the angle between the wires, and thus established there the greatest directional radio activity.

While a scientific truth, or the mathematical expression of it, is not patentable invention, a novel and useful structure created with the aid of knowledge of scientific truth may be. But we do not stop to solve the problem whether it was more than the skill of the art to combine the teaching of Abraham with that of Lindenblad and others who had pointed out that the arrangement of the wires at an angle enhanced directional radio activity along their bisector. We assume, without deciding the point, that this

advance was invention even though it was achieved by the logical application of a known scientific law to a familiar type of antenna. But it is apparent that if this assumption is correct the invention was a narrow one, consisting of a structure conforming to the teachings of the Abraham formula as to angle and wire length relative to wave length, and is to be strictly construed with regard both to prior art and to alleged infringing devices. *Kokomo Fence Machine Co.* v. *Kitselman,* 189 U. S. 8; *Cimiotti Unhairing Co.* v. *American Fur Refining Co.,* 198 U. S. 399. Carter's structure was a V antenna having an angle double the Abraham angle and wires containing a multiple of half wave lengths.

Carter, using the Abraham formula, calculated the value of the angle θ in that formula for wires up to fourteen wave lengths long. He plotted the result, which he expressed graphically in figure 12 of the patent by drawing a smooth curve connecting the discrete points on the graph which indicated the results of his computation by use of the Abraham formula. From this calculation he derived a formula in empirical form[3] for determining the desired angle when wave length and length of wire are known, in which the angle between the wires is described as twice α, which is the equivalent of the angle θ of the Abraham formula.

Petitioner uses antennae with wires in V arrangement, but their wires are not an integral number of half wave lengths long, with the exception of one antenna, No. 8, which is four wave lengths long and uses an angle 10% smaller than that prescribed by the Abraham formula for that length of wire. The others are of lengths which are approximately multiples of quarter wave lengths, and their angles differ from the angles of the formula. The crucial question in the case is whether a V antenna structure, having a wire length to which the Abraham formula does not apply and using an angle not to be derived from that formula, which is the basis of the patent, infringes Carter's patent. Respondent insists that it does, because, as it argues, the invention disclosed by Carter's application, elaborated by amendment and broad claims, embraces all V antennae arranged at an angle double the angle of the empirical formula, even though the length of the wires is not an exact multiple of half wave lengths, as prescribed by the Abraham form-

[3] "For practical purposes the empirical formula

$$\alpha = 50.9\left(\frac{l}{\lambda}\right)^{-0.38} \text{ degrees}$$

is sufficiently accurate where l equals the length of the wire and λ the wave length, both in the same units of measurement."

ula. This is the invention of Claim 15,[4] and it is urged that the claim is amply supported by the statement in the specifications appearing in the original application that the empirical formula represented by the plotted curve of figure 12 of the patent "will be found accurate for all practical purposes where the length of wire dealt with does not correspond to a whole number of half wave lengths."

The trial court, analyzing Carter's application and taking into account the essentials of the Abraham formula and the statement in the application that the "object of the present invention is to disclose the proper angle for conductors or radiators" measured in multiples of half wave lengths, evidently thought, as petitioner argues, that the references in the application to "wires of finite"[5] length and to wires "of any length whatsoever"[6] were intended only to refer to wires of electrically finite as distinguished from electrically infinite length, capable of producing standing waves utilized by the antenna of the patent, and of any length conforming to the requirements of the basic formula.[7] It concluded that the cor-

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4 "15. An antenna comprising a pair of relatively long conductors disposed with respect to each other at an angle substantially equal to twice

$$50.9\left(\frac{l}{\lambda}\right)^{-0.23}$$

degrees, l being the length of the wire and λ the operating wave length in like units, and means in circuit with said antenna for exciting the conductors in phase opposition whereby standing waves of opposite instantaneous polarity are formed on the conductors throughout their length."

Claim 16 claims an antenna arranged in conformity to the empirical formula, as in Claim 15, with "a similar parallel pair of conductors spaced an odd number of quarter wave lengths away from said first mentioned pair . . ." These parallel wires constitute the "reflector", which, as already noted, was old in the art.

5 "Still a further object of the present invention is to disclose the proper angle for conductors or radiators either an even number of half wave lengths long or an odd number of half wave lengths long, and, in general to disclose the angle for best directional propagation for wires of any finite length."

After the present suit was brought this paragraph was amended to read:

"Another object of the invention is to disclose the angle for the best directional propagation for open-ended wires of any finite length, preferably longer than the operating wave length, having standing waves thereon and arranged in the manner proposed."

6 "Moreover, it should be clearly understood that the wires of each unit can be of any length whatsoever provided they are placed at the correct angle for their length. For best tuning, the total over-all length of both of the wires and the 'U' loop terminating them should be effectively an integral number of half wave lengths, but, the portion forming the radiation element can be of any length. The law, giving the correct angle for lengths between odd and even number of half wave lengths, is not given due to its complexity but, the empirical formula and the curve of figure 12 will be found accurate for all practical purposes, where the length of wire dealt with does not correspond to a whole number of half wave lengths."

7 See note 1, *supra*.

rect construction of the application was that the invention described did not go beyond the scope of the Abraham formula and so extended only to the angles calculable by that formula for standing wave wires measured by multiples of half wave lengths. Support is given to this conclusion by the statement in the application that "The law, giving the correct angle for lengths between odd and even number of half wave lengths, is not given due to its complexity . . ."

The Court of Appeals placed emphasis on the reference to "wires of any finite length" and on the statement that "the empirical formula and the curve of figure 12 will be found accurate for all practical purposes, where the length of wire dealt with does not correspond to a whole number of half wave lengths." It held that the invention disclosed was the application of the empirical formula to all lengths of antenna wires and embraced all angles resulting from such calculation, and that the invention was consequently infringed by petitioner's structures.

Whether or not it was the purpose of the patentee, by these references to wire lengths in his application, to extend his patent to structures not conforming to the Abraham formula, we are not able to construe the application, before amendment at least, as embracing such an extension. And we think that the attempt to extend the claims, based on the application of the empirical formula, to wire lengths not multiples of half wave lengths, must fail, ~~both~~ because such structures are not within the invention described in the application ~~and because structures having wires of that length do not in fact exhibit "the angle for the best directional propagation"~~.

The formula in Claims 15 and 16 is the empirical formula derived from the Abraham formula, which is, by its terms, applicable only to antenna wires which are multiples of half wave lengths long. Carter's empirical formula, wholly derived from Abraham's formula, and taken together with it, therefore discloses no invention or discovery more than the application of the Abraham formula to the V antenna. It reveals no scientific law applicable to wire lengths which are intermediate of multiples of half wave lengths, and the application explicitly states that "the law, giving the correct angle for lengths between odd and even number of half wave lengths, is not given". The preparation, by methods familiar to engineers, of the graph in figure 12, which was but a pictorial representation of the Abraham formula applied to certain wire lengths specified in the formula, did not involve invention. Neither the empirical

formula nor its graph gives any clue to the directional radio activity resulting from the use of wire le. ·ths intermediate of multiples of half wave lengths, which were excluded by the Abraham formula, and neither afforded any basis for a claim of invention not supported by the use of the Abraham formula itself.

The claimed use of the empirical formula for the calculation of the angle for wires which are not multiples of half wave lengths long thus involved a departure from what Carter's application had described as his invention, and a contradiction of it. What Carter did was to describe his structure in terms of its dimensions, arrived at by the use of the Abraham formula, which was stated to embody the applicable scientific law. He then derived the empirical formula from Abraham. From the very method of derivation the empirical formula meant nothing different from that of Abraham. He then declared the empirical formula to embody a method of arriving at the measurements of a structure different from the structure first described as the invention and not capable of construction by the method of the Abraham formula. If, as a result of this legerdemain, a V antenna having wire lengths a multiple of any fractional wave length is to be taken as the invention of Carter's application, then everything that it said of the Abraham formula and of wires "either an even number of half wave lengths long or an odd number of half wave lengths long" could be discarded without changing its meaning.[8]

This attempt to broaden the only invention described in the application through a purely mechanical alteration of the meaning of the empirical formula, which had been devised as a shorthand expression of the scientific law on which the invention was declared to rest, cannot, we think, be taken to enlarge the description of the invention as measured by the Abraham formula, so as to include a structure to which that formula does not apply. This use of the empirical formula for a purpose for which it was not devised does not justify our construing the application as though all reference to the Abraham formula had been eliminated and a new and different one expressing a new and different scientific law had been substituted for it. The result of reading the application as respondent contends it should be construed is precisely the same as though full effect were given to a claim which goes beyond the invention described, and it is open to the same objection.

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[8] See note 5, *supra*.

After the present suit was brought the application was altered by amendment so as in effect to wipe out all reference to the scientific law by which Carter's invention was defined. This was accomplished by changes which implicitly assert that the letter *n* of the formula of the invention, the Abraham formula, meant something different from "the number of half wave lengths contained in the wire" of a length of multiples of half wave lengths as stated both in the application and in the patent.

The reference in the application to the purpose of the invention to disclose the "proper angle" for radiators of multiples of half wave lengths long was altered by eliminating from it all mention of half wave lengths.[9] A sentence added after formal allowance of the patent states: "By the term 'plurality of wave lengths' or 'plurality of half wave lengths' or 'several half wave lengths' it is not intended that the wires so described shall necessarily be an exact or approximate integral number of such lengths, unless so specified, but rather that each of the wires so described shall be sufficiently long to include the lengths specified." These amendments operated to modify the Abraham formula so as to cancel from the application the statement of the scientific law defining the invention. They left as its definition the modified Abraham formula and its counterpart, the empirical formula, stating a different law which their genesis did not authorize.

We think that these alterations were not permissible. *Schriber-Schroth Co.* v. *Cleveland Trust Co.*, 305 U. S. —, and that without them the invention must be taken to be limited to a structure having an angle double that disclosed by the Abraham formula, which was made the basis of the alleged invention. As already shown, neither the Abraham formula nor the empirical formula describes, or purports to describe, the directional radio activity or defines the angle which affords "the best directional propagation" of the patent for antennae of wire lengths intermediate of multiples of half wave lengths. The expert testimony shows that in fact neither formula serves that purpose. The finding of the trial court that they do not make "a correct showing of what happens when the wires are other than exact multiples of half wave lengths" is supported by the evidence. The testimony warrants the conclusion that differences in wave effect already noted,[10] when wires

[9] See note 5, *supra.*

[10] See note 1, *supra.*

of other than exact multiples of half wave lengths are used, produce, through consequent changes in "radiation resistance", differences in ~~the angle of~~ directional radio activity not calculable by the formulae of the patent. ~~It establishes that they do not give the angle "for the best directional propagation" for structures using this intermediate range of wire lengths, and that the claimed structures embodying that range of wire lengths defined by use of the empirical formula are therefore invalid~~. It follows that Claims 15 and 16, so far as they claim antennae of wire lengths intermediate of multiples of half wave lengths, are invalid. So far as the patent discloses and claims invention of a structure made in conformity to the Abraham formula, petitioner's structures do not infringe, for none of them conforms to the Abraham formula.

For reasons already indicated it is not material that the variations are small between the angles used by petitioner for wire lengths of multiples of quarter wave lengths and those obtained by application of the empirical formula. Further, Carter's advance over prior art was in specifying an exact angle for wires of the prescribed length. Lindenblad had indicated a preferred angle, and Bruce, before Carter, had plotted a rule of thumb graph, which the trial court found to be prior art, showing the directional radio activity of a V antenna and exhibiting relatively small variations from that of Carter. Carter, avoiding prior art by defining his angle for antennae with wires of particular wave lengths with mathematical precision, cannot discard that precision to establish infringement. *Kokomo Fence Machine Co.* v. *Kitselman, supra; Cimiotti Unhairing Co.* v. *American Fur Refining Co., supra,* cf. *General Electric Co.* v. *Wabash Corp.*, 304 U. S. 364.

It is unnecessary to discuss the further question whether petitioner's structures avoid infringement because the direction of their principal radio activity is not in the plane of the wires, an operative difference from the antennae described by the patent which the court below found to be due wholly to ground effect, which it thought must be assumed to be envisaged by, though not stated in, the Carter patent.

Reversed.

Mr. Justice ROBERTS took no part in the consideration or decision of this case.